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Industrial Relations and Technical Change: Profits, Wages and Costs in the Lancashire Cotton Industry, 1880-1914

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Introduction

The institutional perspective sees the UK's economic decline in the twentieth century as rooted in the rigidities established at the end of the nineteenth. According to Elbaum and Lazonick, the competitive capitalism which had served Britain well in the earlier parts of the nineteenth century failed to transform itself into the corporate capitalism necessary for success by the century's end.¹ From an institutional perspective the Lancashire cotton industry provides a classic example of this predicament. Its first basic weakness, argues Lazonick, lay in its industrial organization.² The vertical specialization that characterized the industry - in particular, the split between cotton spinners and cotton weavers - meant that there did not exist the co-ordination of decision-making necessary to replace traditional methods of production with the new technologies of ring spinning and automatic looms. This, it is argued, was a situation which persisted well into the twentieth century and which saw the industry unable in the end to withstand the pressures of foreign competition.

This view of the nature and impact of the structure of organizations has more recently been called into question.³ Higgins and Toms, for example, have provided evidence which suggests that vertical specialization in the industry was associated with superior financial performance.⁴ Debate on this issue is likely to continue but it is not our intention here to be part of it. If we accept at least that the institutionalist perspective on the relationship between organization structure and competitive advantage is not beyond question, this places a greater emphasis on a second part of their case: the role of industrial relations in the long-term decline of the UK economy.

For Lazonick, the cotton industry in the last quarter of the nineteenth and the first part of the twentieth century was one in which workers were well-organized and able to impose their demands on employers.⁵ In this account, trade unions were able to exploit the system of wage lists around which negotiations in the industry were structured. Employers did derive some benefits from this system - it offered a defence against both damaging price wars and workers' collectively reducing the pace of work - and were to some extent also able to circumvent it by the use of inferior cotton inputs or 'bad spinning'.

Nonetheless, just as in the case of industrial organization, the institutionalist argument is that even into the 1960s management was constrained in technological innovation by the system of industrial relations established at the end of the previous century.

This part of the institutional case thus needs to be considered alongside those who see this system of industrial relations as being of central importance in the UK's more general technological backwardness. Prime amongst these are Kilpatrick and Lawson, who argue that the early acceptance of trade unionism in the UK meant that by the beginning of the twentieth century even 'new' unions of unskilled workers had followed the craft-based unions in establishing customs and norms which predated and thus resisted the introduction of mass production techniques.⁶ The policy of British management was to conciliate rather than challenge this power, the effect being to damage the economy's capacity for innovation and hence its potential for growth.

These views have not of course gone unchallenged. For one thing, the Kilpatrick and Lawson thesis suffers from a lack of supporting evidence. They make reference to a number of industry case studies but on closer examination these appear to offer them little support.⁷ Other authors have attacked the arguments themselves. Coates drew attention to the "employers' offensive" of the 1890s, and argues also that it is 'almost impossible' for any substantial workplace power possessed by trade unions to have survived in the widespread and persistent unemployment of the 1920s and 1930s.⁸ Hyman and Elger argue that Kilpatrick and Lawson's is an 'over-romanticized' view of British working class strength, one which ignores the limited nature of any gains it was able to make.⁹ Dintenfass emphasizes how in many cases trade unions collaborated with management in such industries as engineering, cotton and coal.¹⁰

The objective of the present paper is to add weight to those who take issue with the idea that it was employee strength and recalcitrance in the cotton industry that led to its failure to innovate and, in turn, to its long-term decline. To do this the paper divides into three main parts. The first of these examines the transformation in industrial relations in the half century before 1914. It evolved in this period from an individualistic, sometimes paternalistic environment in which Utopian inspired co-operative organizational structures briefly flourished, into a highly institutionalized, federated system.

In the second main part of the paper we turn to the balance of power within this system of industrial relations. The evidence presented is drawn from accounting records, a source not commonly exploited in labour history. Such neglect would be surprising in any case, given the usefulness of this type evidence for assessing the outcomes of bargaining processes. It is particularly surprising in the case of the cotton industry in this period, for it is precisely around issues of accounting information that the system of industrial relations was structured.

Using similar accounts-based data, the third main part of the paper addresses the question of technological change more directly. The evidence presented here suggests that because employers were doing well out of the existing system they had little incentive to introduce new technologies. A full examination of the labour costs associated with the spinning process - taking into account the necessary attendant processes as well as the spinning itself - shows that the introduction of the new ring-spinning technologies was difficult to justify. In looking for an explanation of the Lancashire industry's technological 'backwardness', we conclude, it is thus at employer policy rather than employee resistance that our attention should be directed.

From Co-operative Organization to Industrial Relations

The co-operative principle upon which many Lancashire business organizations had been founded since the 1840s reinforced the subsequent development of 'working class limiteds'.¹¹ Their rise and fall had important implications for the evolution of industrial relations in the cotton industry which are analysed in this section.

The experience of the Rochdale 'pioneers' in distributive co-operatives encouraged similar ventures in the field of production. A prominent example, the Rochdale Co-operative Manufacturing Society, later known as the Mitchell Hey mill was established as a co-operative in 1854. All the promoters were members of the Society, and all employees were shareholders and surpluses were paid as a bonus to labour.¹² Similar developments six years later led to the establishment of the Sun Mill Company, formed in 1859. Its founders, the members of the Oldham Industrial Co-operative Society, led by the idealistic William Marcroft, gave the new company a democratic structure designed to foster the principles of producer co-operation and employee control. Management of the company was by means of elected committees, for example along the lines of responsibility for different parts of the balance sheet, namely the 'Fixed Stock' and 'Saleable Stock' committees.¹³

Such democratic principles obviated the need for shopfloor trade union organization and must at least partly explain why Oldham District operatives shunned industry-wide trade unions in the 1850s and 1860s.¹⁴ Union organization remained problematic for several decades due to worker share ownership in the new 'democratic' limiteds. The limited liability principle, to which the co-operators also subscribed following the Companies Acts of 1856 and 1862, was seen as an adjunct of co-operation. Working class investment was thereby reinforced and following the notation of sixty new mills in the 1873-5 period, the methods of organization, management and accounting were direct imitations of the co-operative societies.¹⁵ Thus in 1873 75% of shares in these mills were owned by working class investors, although this proportion declined towards the end of the decade. A couple of years later total investors in Oldham numbered 10,000, or one in five of the population.¹⁶

Contradictions in co-operative principles meant that the prominent experiments were shortlived. Thus few workers owned shares in their own companies for long. When Gladstone visited Sun Mill in 1867 only 4 out of 1,000 shareholders were also employees and he observed '... this company is not really a co-operative one, but an association of small capitalists'.¹⁷ At Mitchell Hey, the co-operative principles also began to decline in the 1860s. As is common with many co-operative organizations, scale and industrial democracy acted in contradiction.¹⁸ A new group of working class shareholders created through a share issue for a second mill, objected to the payment of dividends to labour. As many worked at other mills, where they had no similar right to these bonuses, they were keen to end the practice. In 1862, after two previous unsuccessful votes, a majority succeeded in abolishing the labour bonus principle.¹⁹ Nonetheless, cotton operatives continued to be significant contributors to the share lists of other companies floated under the limited liability acts²⁰ and these early associations had an important influence on the development of industrial relations in Lancashire.

The 1870s was a transitional decade in this respect, with two conflicting forces at work; the traditional institutional structures of co-operation and the adoption of wage

lists. Democratic governance structures were adopted which meant that characteristically there was wide public participation at company meetings, in new issues, and in the buying and selling of existing shares.²¹ Democratic structure was maintained via a 'one member one vote' system at quarterly shareholders' meetings. Directors' salaries were kept to a small fraction of those earned in other industries in companies owned by, as Potter put it, 'upper class shareholders'. Democratic norms were further underpinned by mechanisms such as limits on maximum shareholdings, proxy holdings and anonymous institutional or nominee investors.²² At the same time, the expertise and technical knowledge became increasingly important for both worker/shareholders and operatives. For the former participatory governance mechanisms provided the opportunity to apply shopfloor based scrutiny thought by some to contribute towards improved efficiency.²³ For the latter, the emergence of the list system meant increasing reliance on union officials who were skilled technicians. Like 'the valuer or accountant' such experts took a highly professional form. For the overwhelming majority of Oldham operatives, it was reliance on union officials rather than participation in company management that became the *modus operandi*. The trade cycle, 'is associated with uncertainties and the redistributions of wealth, was the driving force. The depression of 1877-9 discouraged working class equity investment as share values fell although the companies themselves survived.'²⁴ As union membership increased working class equity investment declined, the worker-shareholders with suspicion on the shop floor.²⁵ Meanwhile, booms tended to be associated with the promotion of more secretive, narrowly controlled companies.²⁸ Working class disillusionment with share ownership became complete in the 1800s which saw 'unparalleled depression and of severity and duration.'²⁶ Between late 1890 and early 1895 an index of the Oldham stock market fell almost continuously for forty eight months, before finally reaching a pro war low in March 1896.²⁷ Poorer investors were unable to meet calls from the cash strapped limited companies and former share owning operatives turned increasingly to the security offered by trade union organization.

The Balance of Power in Industrial Relations: Evidence from Outcomes

The Brooklands Agreement

The period 1870 to 1890 had witnessed several important trends. These were a shift from North East to South East Lancashire as the main focus of developing trade union Organization³¹, the adoption of wage lists, the decline of employer paternalism and the linked rise of employer federations, and the rise of federal bargaining structures. Increasingly tempestuous industrial relations culminated in the 'Brooklands Lockout', the subsequent agreement in 1893 and the institutionalisation of bargaining thereafter. An important feature of the new system was its promotion of employer and operative collaboration to further collective interests, for example through political lobbying.² The pattern of dispute and the agreements that ended them, were predicated on the vulnerability of the industry to the business cycle.³² Therefore the Employers' Federation had a strong incentive to suggest that profits were lower than they really were³⁴. While the operatives, and especially the Spinners, were wedded to an economic doctrine that suggested these profits fixed the maximum possible wage.³⁵ Such a combination of

attitudes suggests, given the asymmetry of accounting information, the employers were in a better position to exploit the new bargaining structures and that despite their creation of a closed union labour aristocracy, the operative spinners representatives were in a poor position to protect the wages of their members. In this section we explore this possibility through an analysis of winners and losers following the agreement.

In response to Brooklands, employers increasingly centralized the indoor management of their companies. As the problems of agreeing as to the 'state of trade' persisted into the 1900s,³⁶ directors' coups eliminated the last vestiges of democratic ownership in the Oldham companies. From now on it was necessary to operate with greater secrecy towards the workforce.³⁷ With centralization of capital ownership came growth in employer associations. Previously democratically controlled companies became the driving force first with the establishment of the centralized United Cotton Spinners Association and later the Federation of Master Cotton Spinners Associations.³⁸

As the demands of workers and employers became increasingly channelled into formalized bargaining structures, it is interesting to speculate as to which side tended to benefit the more. The evidence suggests that despite increasing solidarity expressed through shop floor organization, the employers benefited more from the Brooklands compromise. At the agreement institutionalized piece rates, wages remained linked to the efficiency of the industry and were also variable depending on the stage of the trade cycle.

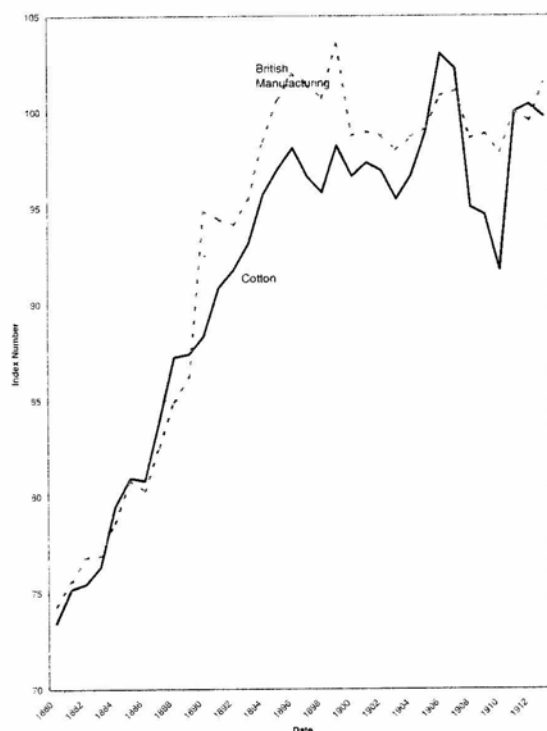
Trends in Real Wages

These reasons partly explain why at a time when cotton profits were better than in the rest of the economy, particularly in the period 1896-1914, Lancashire cotton operative achieved smaller increases in real wages than did workers in other sectors.³⁹ Table shows that as profits for British industry as a whole declined, the cotton sector experienced a rising trend. Unlike other sectors by and large, especially in its dramatic climax of 1907, returns were quite spectacular⁴⁰ and must have had a profound influence on the cotton investor. Whereas cotton investors were rewarded by far better returns after 1896 the picture for employees was more ambivalent. As for the rest of the economy, the

Table 1: *Rates of return to capital, British cotton and manufacturing*

	% Five year average return to capital	
	British industry	Cotton
1885-89	14.50	5.74
1890-94	11.30	5.70
1895-99	10.80	7.56
1900-1904	7.10	6.13
1905-9	7.20	11.72
1910-13	7.90	8.63
Whole period	9.87	7.61
Std dev	2.68	3.96

Sources: Cotton industry, Toms, thesis, p. 28; British industry averages, Davis, Huttenback, R., *Mammon and the Pursuit of Empire: The Economics of British Imperialism* (Cambridge, 1988), p. 117.



Sources: as for Table 2

Figure 1: Real Wages, 1880-1913

upward trend in real wages, defined in terms of the difference between money wages and the cost of living, which had begun with the industrial revolution, came to an apparent end after 1900 (Table 2 and Figure 1).

Table 2: Real wages, 1880-1913

	Percentage annual growth rate		
	Cotton Industry	Manufacturing Industry	British Industry
1882-1899	1.48	1.67	1.71
1900-1913	0.23	0.19	0.58

Sources: Cotton and manufacturing, calculated from Feinstein, 'New estimates of earnings' table 4, pp. 608-11 and 'A new look at the cost of living', table 4 pp. 170-1; UK economy, Feinstein, 'What really happened to real wages', table 4, p. 344.

The trend in Figure 1 has important implications for our understanding of the evolution of industrial relations. Especially in the spinning section, cotton trade unions have been considered a good example of a craft based labour aristocracy.⁴¹ However, the evidence in Table 2 and Figure 1 suggests that cotton workers were poorly rewarded relative to the manufacturing sector as a whole and the economy in general. Manufacturing was

affected as much by the spread of general unionism as it was by the retention of craft control,⁴² whereas the general economy included a growing class of professional and salaried workers hitherto unrecognized in the construction of real wages indices.⁴³ Although the breaks in trend occurred for both cotton and manufacturing around 1900, cotton had been lagging behind for about a decade. We have commented elsewhere that cotton suffered badly in the depression of the early 1890s, and it is evident from figure 1 that contemporaries were incorrect to blame the trade unions for the plight of the industry and the crash in share values,⁴⁴ as relative wages were falling, albeit perhaps not as steeply as the employers would have liked.

If the Brooklands agreement had stabilized industrial relations,⁴⁵ it did so at the expense of the stability of wages themselves. By implicitly linking wage advances and reductions to the trade cycle, but at the same time limiting them to one per year and to a maximum of five per cent,⁴⁶ the agreement helped ensure that wages fluctuated, but with nothing like the variation in profits. Thus cotton wages raced ahead in the boom of 1904-7 relative to other groups, but then fell dramatically again in the slump of 1909-10. However, in relation to generally improving profits, the share of extra wealth accruing to labour was low, and adjusted only slowly so that the benefit of the 5 advance of June 1907 was shortlived and by July 1908 the employers were already pushing for a reduction.⁴⁷ Support for trade federations and collective action on wages must have contributed towards higher profits for the rising class of cotton financial capitalists, and probably outweighed the benefits of previously paternalistic management style.⁴⁸ In so far that this was a deliberate and forced response to an apparent increase in the bargaining power of the operative - s,⁴⁹ the Brooklands agreement would appear to have been an effective management response for the maintenance of profitability. The 'company town' and paternalistic management styles were declining in this period,⁵⁰ and the attractiveness of the new bargaining system and its associated employer solidarity may have accentuated the process.

For cotton workers, craft unionism and its industry wide accommodation with employers' federations at Brooklands, thus appeared to offer little benefit. The Leninist argument of 'embourgeoisification',⁵¹ the rising wealth of the working class creating a mood for the acceptance of reformist ideas, did not apply in the strict sense. Election of reformist trade union officials before 1890, according to one view, was the result of narrowing margins after 1873 and the need felt by employers for an industrial detente.⁵² Mutual interest policies culminated in the compromise at Brooklands when Macara and Mawdsley, representing the two sides, struck up a lasting friendship, and an agreement which, 'pointed the way ... to that industrial harmony which arises from wise statesmanship and eschews the weapon of force'.⁵³

However, the union leaders' policies of employer collaboration subsequently created conditions which led a relative fall in real wages for cotton operatives in the 1900s at a time of rising profits for the employers. Even so, as the conditions which had led to the rise of collaboration went into reverse, there was no return to increased militancy. From 1893 the characteristic mood was of 'industrial peace';⁵⁴ even the boom of 1907 failed to produce strikes associated with wage demands, and signs of growing disaffection were only apparent in the very last years before the 1914-8 war.⁵⁵ Overall it is difficult to conclude that the system of industrial relations acted as a barrier to cost cutting employer strategies.⁵⁶ The Brooklands system provided the employers with a satisfactory mechanism for keeping wages under control.

The Shift to Profits

Although generalization about trends is difficult where the trade cycle played such an important role, the real wages trend is suggestive of a shift to profits at the expense of wages. A rising trend of return to capital and of cotton share prices⁵⁷ in conjunction with Figure 1 suggested that capital gained at labour's expense in the 1900s. Evidence from the accounting records of cotton companies provides tentative support for this hypothesis (Table 3). Using profit and loss account data, the proportions of net value added⁵⁸ shared by capital (measured by profit, interest and depreciation) and labour (wages and salaries) were calculated and compared for two dates, 1898 and 1912.⁵⁹ Between these dates the real wage trend was relatively flat (Figure 1). Averaging calculations for the six years before 1898 and 1912 suggested that the figures were representative. The results of these calculations are shown in Table 3.

Table 3: *Capital, labour and value added, 1898–1912.*

	Spinning		Weaving	
	1898	1912	1898	1912
(1) Percentage shares of value added				
Wages	55.7	54.4	79.7	75.4
Capital	44.3	45.6	20.3	24.6
	100.0	100.0	100.0	100.0
(2) Percentages to sales				
Wages	15.1	10.8	23.2	15.4
Material	65.1	73.1	62.3	75.1
Capital	11.8	8.8	5.9	5.1
Other Expenses	8.0	7.3	8.6	4.4
	100.0	100.0	100.0	100.0

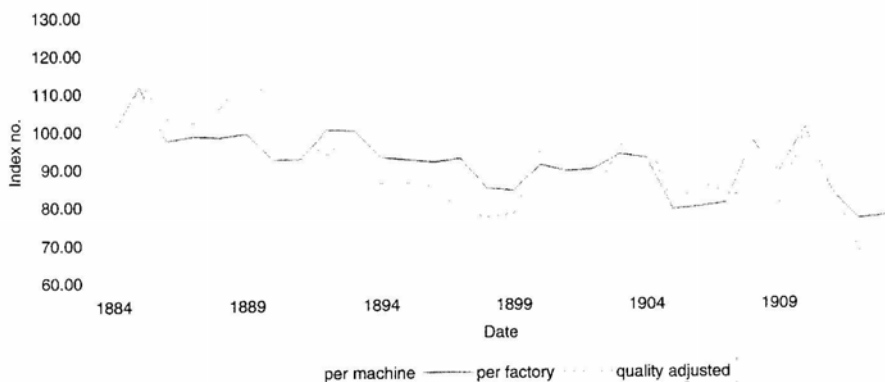
Sources: Calculated from company accounts, sources per table 1.2. (1) For each company and for each year, material and non wage expenses (excluding profits, interest, and depreciation) were subtracted from sales to obtain value added. Wages calculated as percentage of value added with capital share treated as the residual. (2) Each profit and loss expense item calculated as a percentage of sales. Capital defined as the total of profits, interest and depreciation.

Data presented in Table 3 confirm the hypothesis of a shift to capital. However, the shift was very slight, and since evidence was available for only five companies in total, it would be wrong to attempt to read too much into the figures. The safest interpretation might be that there was at least a stability in the respective shares of value added but more likely a shift to capital. At a national level the shift to capital hypothesis has been supported by considering the rising trend in interest rates in conjunction with the flat trend in real wages.⁶⁰ Use of new data has called this interpretation into question, and it has been argued that nominal GDP per worker was rising in the Edwardian period.⁶¹ However, the likelihood of sectoral variation was also suggested, in particular cotton, which might have experienced a shift to profits on the basis of its export boom.⁶² Accordingly investors and entrepreneurs experienced substantial rewards in this period

via rising share prices in Lancashire and increased returns to capital, in contrast to the relatively slower increase in real wages.

Productivity Trends

Workers did even worse relatively if increases in productivity, which the list system supposedly ensured were shared between the two sides of industry, are also taken into account. Figure 2 charts an improvement in efficiency as a function of quality improvements and the development of larger factories. It also shows that where output was measured purely on a per spindle basis there was no clear trend for capital output ratio and therefore no apparent improvement in productivity.⁶³ However, this is too simplistic, as it ignores both factory layout and economies of scale associated with putting more mules or looms into larger factories, as well as any effective slowing down of machines associated with increased quality.⁶⁴ Where output was calculated in relation to the number of factories, the resulting capital output ratio declined steeply (Figure 2). Furthermore, if output quality is taken into account, there was a further decline in the capital output ratio. Overall, the line which tends to slope downwards most prominently from left to right in Figure 2 is that which shows the combined effects of quality and larger factories.



Sources: Based on yarn produced and consumed, machines on an index of spindles and looms (1 loom weighted at 60 spindles) and no. of firms per Jones, *Increasing Return*, p. 277; output adjusted for quality per Sandberg, 'Movements in quality', pp. 10-11.

Figure 2: Capital Output Ratios, 1884-1913

All three measures in Figure 2 show downward slopes and cyclical effects of varying degrees. Factors such as machine speed ups, mule lengthening, factory layout, and quality shifts created the opportunities for marginal improvements in capital productivity. For labour productivity, the cyclical character of the industry makes measurement more problematic. During upswings the industry apparently became much more efficient as full capacity was approached.⁶⁵ Corresponding declines occurred in the troughs of recessions, but over a longer period the increase in productivity is still apparent.⁶⁶ On the output per operative basis steep increases in productivity occurred during the upswing of the trade cycle, as acknowledged by Sandberg.⁶⁷ The use of labour productivity evidence

from this period to prove stagnation in the industry is thus questionable. What appears clearer is that the institutionalized wage bargaining system protected employers from wage advances in periods of higher capacity and rising productivity.

The shift from labour to capital suggested above appears more convincing when considered in relation to productivity data. This is confirmed further by the statistics in Table 4. In spinning, capital was very rapidly attracted in the 1900s in response, no doubt to increasing levels of profitability and output. Also this was influenced by regulated wages and a labour cost function that was slow to rise in periods of prosperity. Labour input meanwhile grew only slowly in the period 1890-1914 and declined somewhat in the 1890s. In weaving there was also a loss of labour input during the years of depression. However, when the recovery came, it was this section of the industry, with its predominantly female labour force,⁶⁸ which saw a major expansion in numbers employed. In the unprecedented export booms of 1905-7 and 1911-13, there was an over commitment of capital in the case of spinning, and labour in the case of weaving.

Table 4: Cotton industry; total factor productivity, 1884-1913.

(1) TFP analysis - spinning

	Output	Labour	Capital	Residual
1884-1899	1.18	0.52	0.47	0.19
1900-1913	1.56	0.52	0.46	0.58
Overall	1.58	0.48	0.49	0.61

(2) TFP analysis - weaving

	Output	Labour	Capital	Residual
1884-1899	1.34	0.62	0.30	0.42
1900-1913	1.39	0.61	0.30	0.48
Overall	1.67	0.57	0.28	0.62

(3) Annual compounded growth rates (%)

Spinning

	Output	Labour	Capital
1884-1899	1.04	-0.39	0.25
1900-1913	3.23	1.07	2.27
Overall	1.54	0.29	1.22

Weaving

	Output	Labour	Capital
1884-1899	1.85	-1.16	1.15
1900-1913	2.38	3.04	1.37
Overall	1.74	0.77	1.29

Sources: Output, spinning yarn production per Jones, *Increasing return*, table II, p. 275, weaving, cotton piece goods exports per Robson, *The cotton industry in Britain*, table A1, p. 331. and as adjusted by the yarn and cloth quality indices respectively, per Sandberg, 'Movements in the quality', tables 2 and 4, pp. 10-11; capital based on index of total capital employed, sources as per figure 2; capital and labour weights in (1) per table 10.5; labour data as per table 10.7.

Industrial Relations and Technical Change

Our analysis so far suggests that it is unlikely that it was trade union strength that accounted for British firms' reluctance to adopt the new production technologies. Having also cast doubt on the idea that vertical specialization in the industry was the key factor, we turn now to a more direct consideration of firms' decisions in this area. According to the Lazonick hypothesis, saving on raw material input was an important reason for adherence to the mule. Trade union inflexibility and the minder-piecer system prevented the reorganization of work to achieve labour cost savings; at the same time the system was threatened by the availability of ring spinning. Masters and men therefore co-operated to achieve the best productivity possible through raw material savings, for example in the agreement for bad spinning compensation in the Brooklands agreement of 1893.⁶⁹

Whilst providing a plausible theory, this argument is not backed by evidence from Rochdale, the early centre of British ring spinning. It is noteworthy first of all that those making the experimental moves in ring spinning did not cite labour cost as a source of saving. Rather, the Rochdale entrepreneurs justified their investment in rings in terms of savings in raw material input without any loss of quality, low breakdown and maintenance cost, and the relative cheapness of the machinery.⁷⁰ In Rochdale, and elsewhere, raw material saving was given as a key reason for the introduction of the ring. Had Lancashire entrepreneurs wished compete against the threat of low wage competition from overseas on the basis of savings in raw material input, the ring spindle would have given them the means of doing so for the lower range of counts.

On the other hand, using the ring spindle did not provide the early ring spinning companies with an easy way round the increased institutionalization of industrial relations. Their entrepreneurs relied on paternalism rather than exploitation, but at the same time sought solidarity with employers elsewhere in the industry. Such contradictions were keenly felt throughout Lancashire, especially where joint stock companies were prevalent.⁷¹ As elsewhere, Milnrow, the location of the earliest ring spinning companies, had many of the characteristics of a 'company town'. Like the Ashtons of Hyde and the Fieldens of Todmorden, the Heaps of Milnrow exercised a good deal of local deferential and political influence, as manifested in the local reaction to the death of the founding entrepreneur.⁷² Yet only a few days earlier the hands employed at his New Ladyhouse, the New Hey and the Haugh spinning mills had been placed on a week's notice. Local management acted at the behest of the Masters' Federation, which had decided to stop the mills until the settlement of the Stalybridge dispute. In addition to the Milnrow ring spinners, mule spinning mills such as the nearby Garfield were also involved.⁷³ Whatever reason Heap and Tweedale had for promoting the ring spindle at Milnrow, it was not because they sought to drive down wages, nor was it to escape from the increasingly institutionalized structure of labour relations.

In order to gain further insight, and to reassess the apparent contradictions arising from the above discussion in further detail, it is useful to compare actual cost structures of ring and mule companies. Ring and mule labour cost statistics for the late 1880s and early 1890s, based on the Milrow companies and other mule and ring mills in nearby Oldham, show that the labour content of their output was actually higher in the 1880s and 1890s than for mule spindles.⁷⁴ Unlike the paternalist managements of

the Milnrow mills, potential emulators may not have had a generous attitude towards expensive, and perhaps locally scarce, ring spinning labour. Comparative data, in terms of spindles per hand also suggests the early ring spinners had a greater labour intensity than mule spindle concerns. The higher productivity of ring spindles meant that labour formed an approximately equal proportion of total cost. Expensive labour in the context of ring spinning directly contradicts the usual understanding of the development of this technology.

Labour cost savings, given the faster speed of the ring spindle, may have been available in the spinning process itself. However, ring spinning required more labour in roving and other preparation stages and in subsequent processes, such as doffing and winding.⁷⁵ Where ring spinning developed from throstle spinning, as in Rochdale and other areas, there was a tradition of labour intensity, particularly with regard to doffing.⁷⁶ Doffing was an unskilled task and was usually carried out by teams (four per machine) of young and inexperienced workers.⁷⁷ It was their employment that to the apparent labour intensity of ring spinning. Evidence from the Rochdale district can be corroborated by international comparisons. A ring spinning mill in France in 1882 producing 30s twist had a spindle per operative ratio of 75, ⁷⁸ and was thus directly comparable in labour intensity with the New Ladyhouse spinning company at ⁷⁹, but well below the level of 206 achieved by the typical Oldham mule spinner.

That labour cost saving was not a strategy associated with the introduction of ring spinning was confirmed by contrasts of costs between the ring mills themselves. The New Ladyhouse mill was the most profitable of the three Milnrow concerns, yet it was also the most labour intensive.⁷⁹ Profits may have been improved by the relatively low average wage, which in turn may have reflected the application of piece rates to at least some of the hands. Even so, workers were paid more here on average than in the strongholds of labour aristocracy in the mule mills of Oldham. James Heap would have been regarded as a generous employer and the public grief apparently expressed by the whole town on his death may have run deeper, and for reasons beyond those of pure paternalism, than guessed at by the newspaper correspondent.⁸⁰ Expensive labour cost may have been compounded by the absence of a comprehensive, institutionalized wage list coupled with the relative scarcity of ring spinners. Highly individual lists for ring spinners existed by the early 1900s. Following industrial action, the final moves towards a universal official list for ring spinners' wages were not made until 1912.⁸¹ Moreover, the same factor may have led to variation in wages over time and by geographical area. Thus, although wage structures were important, as far as the early experiments in ring spinning were concerned, they were not decisive. The new ring mills might well have employed female labour and probably young girls to doff the machines; they were hardly sweatshops though, and labour cost savings were patently not the reason for the introduction of ring spinning.

Relative expense of ring mill labour may also have been a product of cheap labour in the mule spinning section of the industry. As an oft quoted example of a labour aristocrat,⁸² relatively high wages in the mule room were confined to the senior minder. Out of his own wage, he would effectively sub-contract his two assistants, the big piecer and little piecer, both of whom depended on promotion up this hierarchy.⁸³ Both earned relatively low wages,⁸⁴ and would have depressed the average wage per hand. Thus expensive and cheap labour existed side by side. Whereas the subcontracted payment system might create

the risk of double counting when using industry data, and although there was no evidence of this,⁸⁵ firm specific published accounting reports could be relied upon to contain only the net labour cost to the firm.

Table 5: Gross margins, ring and mule mills, 1892

	COMPANY		
	RING	MULE	
	Haugh	Hathershaw	Oldham Twist
	£	£	£
Sales	17,572	23,798	38,092
Cotton cost and charges	12,221	17,491	28,573
	%	%	%
Margin	69.49	73.50	75.0
	RING	MULE	
	Fielden	Werneth	Osborne
	£	£	£
Sales	13,209	28,378	7,981
Cotton cost and charges	9,094	20,981	5,350
	%	%	%
Margin	68.85	73.93	67.03

Note:(1) For Fielden, in the absence of 1892 data, 1895 was used.

(2) Werneth prepared its trading account on a receipts and payments basis and its purchases fluctuated dramatically, therefore a quarterly average was used based on the previous eight quarterly results.

(3) In all cases raw material costs were adjusted for changes in stock levels.

Sources: Haugh, Hathershaw, and Oldham Twist, calculated from *Oldham Chronicle*, 'Commercial Notes' 2nd January, 1892; Fielden, RMA, 1895; Werneth, OLSL, Misc/42/17, Quarterly reports to members; Osborne, LCRO, DDX/869/3/1, trade, capital and profit and loss accounts.

As noted above, saving of raw material input using ring spindles was thought to be important by entrepreneurs. Rings were acknowledged to be more productive on the lower count range.⁸⁶ That argument was well supported by evidence from accounting records, with raw material accounting for a significantly lower proportion of production cost in ring mills.⁸⁷ Table 5 provides a collation of data showing sales, cotton costs, and profit margins for ring and mule mills. When compared with mule mills spinning low counts, such as Hathershaw and Oldham Twist, ring mills tended to show a 4-7% superiority in margin.⁸⁸ The comparison was flawed however, as even lower count mule mills were producing higher counts than the ring mills, and also weft yarns. Taking into consideration count differentials, the advantage for ring mill margins would have been greater. Only when compared with Osborne, a fine spinner by Oldham standards and therefore operating on above average margins, did the advantage disappear.⁸⁹ High labour cost, averaging just under 15% of total cost, cancelled out the benefit for this company on raw material value added. At the coarse end of the market, margins were much narrower, and hence the ring spinners benefited from higher productivity per unit of

cotton input, without having to increase their prices. Bearing the above interpretative difficulties in mind, the superiority of the ring on raw material usage clearly made a net contribution to company profits.

Another factor influencing cost structure was lack of industry concentration, and the very small market share of each firm. Under such circumstances high levels of fixed cost create disproportionately large losses as output falls in a recession. Increasing the scale of operations would accentuate such risks. There was thus a strong incentive to avoid ring spinning where, despite some tentative evidence for the use of piece rates at Milnrow, time based wage rates predominated. By contrast mule spinning was attractive, since labour was paid according to piece rates and the Brooklands agreement specifically allowed wage rates to vary with the trade cycle.⁹⁰ Fixed cost was also avoided through vertical specialization, allowing management and administrative costs to remain minimal, the market acting as the co-ordinating mechanism.⁹¹ Lazonick has argued that investment in rings was more likely to occur in integrated firms developing high throughput production.⁹² However, under the highly variable demand conditions imposed by the trade cycle, the last thing entrepreneurs needed was the high fixed cost structure that such investment implied.

Previous discussions of the relative merits of ring spinning which have used labour cost in their analysis have thus concentrated too narrowly on the spinning process itself. Under British conditions, if wage cost was a barrier to competitiveness, labour intensity in preparatory and after spinning processes must have been an important reason for the coexistence of the ring and mule for a further generation. In its early years at least, ring spinning was not a route for substitution of labour by capital.

Conclusions

The evidence presented in this paper allows us to consider afresh the issues raised in the introduction. Our first conclusion concerns the state of industrial relations and its impact on the diffusion of new technologies. Union inability to defend real wages and seek major advances in buoyant trading conditions, and where there were increases in labour productivity, may mean that trade unions were weaker than hitherto recognized, that the Brooklands agreement was generally favourable to the employers, and that unions would not have been able to mount any serious challenge to a determined employers' bid to replace mules and power looms with alternative technologies. For industrial relations, this was the opposite to what happened in the period 1867 to 1885, when there was a shift from capital to labour.⁹³ According to one view, this put pressure on employers and forced them into industry wide bargaining at Brooklands.⁹⁴ It would be difficult to blame unions for failure to make investments in alternative technology since their power to resist was low.

Our second conclusion reinforces the first. Looking at the costs associated with the different technologies, the evidence shows that as ring spinning was actually more labour intensive than mule spinning, it could not have had any great appeal to employers seeking to displace labour or circumvent the increasing institutionalization of wage negotiations. Commercially, the superior profits enjoyed by the Milnrow companies resulted from savings on raw material inputs, an advantage that would have been shared by other ring spinning companies. If we are trying to explain why the Lancashire cotton industry

appeared slow to adopt the new technologies available to it, it is on the decisions of employers rather than the recalcitrance of employees that our attention should focus.

Notes

1. B. Elbaum and W. Lazonick, 'The Decline of the British Economy: An Institutional Perspective', *Journal of Economic History*, Vol. XLIV, No. 2, 1984, pp. 567-83; B. Elbaum and W. Lazonick, 'An Institutional Perspective on British Decline', in B. Elbaum and W. Lazonick (eds), *The Decline of the British Economy* (Oxford: Oxford University Press: 1986).
2. W. Lazonick, 'The Cotton Industry', in Elbaum and Lazonick, *Decline of the British Economy*, pp.18-50.
3. G. Saxonhouse and G. Wright, 'New Evidence on the Stubborn English Mule and the Cotton Industry, 1878-1920', *Economic History Review*, Vol. 37, pp. 507-19; G. Saxonhouse and G. Wright, 'Stubborn Mules and Vertical Integration: the Disappearing Constraint?', *Economic History Review*, Vol. 40, pp. 87-93.
4. D. Higgins and S. Toms, 'Firm Structure and Financial Performance: the Lancashire Textile Industry, c. 1884-0. 1960', *Accounting, Business and Financial History*, Vol. 7, No. 2, pp. 195-232.
5. Lazonick, 'Cotton Industry', pp. 24-27.
6. A. Kilpatrick and T. Lawson, 'On the Nature of Industrial Decline in the UK', *Cambridge Journal of Economics*, Vol. 4, pp. 85-102.
7. In this category we can include the following: M. Berg (ed.), *Technology and Toil in Nineteenth Century Britain* (CSE Books: 1979); R. McKersie and L. Hunter, *Pay, Productivity and Collective Bargaining* (Macmillan: 1973); J. McLean and H. Rush, 'The Impact of Microelectronics on the UK: a Suggested Classification and Illustrative Case Studies', *Occasional Paper Series 7*, Science Policy Research Unit, University of Sussex.
8. D.Coates, *The Question of UK Decline* (Harvester Wheatsheaf: 1994).
9. R. Hyman and T. Elger, 'Job Controls, the Employers' Offensive and Alternative Strategies', *Capital and Class*, Vol. 15, pp. 115-49-
10. M. Dintenfass, *The Decline of Industrial Britain 1870-1980* (Routledge: 1992).
- n. T.Eilison, *The Cotton Trade of Great Britain*, London: Frank Cass (1886; Reprinted: 1968), p. 134; B. Potter, *The Co-operative Movement in Great Britain*, Aldershot: Gower (1891; Reprinted, 1987), pp. 126-133
12. *Rochdale Observer*, 10 May 1890.
13. R. E.Tyson, 'William Marcroft', in D.Jeremy (ed.), *Dictionary of Business Biography* (London: Butterworths: 1984-6), p. 121; R. E. Tyson, 'Sun Mill- a Study in Democratic Investment' (unpublished M.A. Thesis, University of Manchester: 1962) p. 230.
14. *The Amalgamated Association of Cotton Spinners*, formed in 1853; Webb, *The History of Trade Unionism*, p. 307.
15. D. A. Farnie, *The English Cotton Industry and the World Market*, Oxford 1979, p. 247-9; Tyson, 'William Marcroft', p. 121.
16. Farnie, *English Cotton*, p. 250.
17. Tyson, 'William Marcroft', p. 121. In 1886 several witnesses to the parliamentary Royal Commission pointed out that there were very few operatives who owned shares, particularly in their own companies (Royal Commission on the Depression o/ Trade and Industry, Reports and Minutes of Evidence (1886), for example, q.5i31)-
18. M. Aoki, *The Co-operative Game Theory of the Firm* (Oxford, Clarendon Press:i984) pp. 54-5.
19. *Rochdale Observer*, 10 May 1890.
20. S. Chapman, *The Lancashire Cotton Industry* (Manchester, Manchester University Press: 1904), p. 231. Those seeking the reconciliation of capital and labour via the worker/shareholder mechanism in the i850s from various political perspectives were prominent in calling for the introduction of limited liability, J. B. Jefferys, *Trends in Business Organisation in Great Britain*

- since 1856, with Special Reference to the Financial Structure of Companies, the Mechanism of Investment and the Relations between the Shareholder and the Company (unpublished Ph.D. thesis, London University: 1938), p. 33; Select Committee, 1850, q. 837, although admitting that workers potentially had a problem with control over each other and their managements (*ibid*, q. 840)
21. Active participation at meetings was always an important feature of the co-operative movement; J.Foster, *Class Struggle and the Industrial Revolution* (London, Methuen: 1974), p. 222.
 22. J. S. Toms, *The Finance and Growth of the Lancashire Textile Industry, 1870-1914* (unpublished Ph.D. thesis, University of Nottingham: 1996). In 1912, ratios of directors emoluments to sales for a sample of privately controlled cotton companies ranged from 7.15 per cent at Fielden Brothers (Todmorden) to 1.98 per cent at T and R Eccles (Blackburn) and 1.22 per cent at Horrockses (Preston), West Yorkshire Record Office (WYRO), €353/475, Detailed Accounts, 1890-1914, Lancashire County Record Office (LCRO), 868/7/1, Profit and Loss Accounts and Balance Sheets, 1897-1931, LCRO, DDHs/53, Balance Sheets, 1890-1919; in Oldham, Werneth at 0.34 per cent (calculated as above) was more typical, see B. Potter, *The Co-operative Movement in Great Britain* (Aldershot: 1891; Reprinted: 1987).
 23. R. Smith, 'An Oldham Limited Liability Company, 1875—1896', *Business History*, December, Vol. 4 (2) (1961) p. 41.
 24. Ellison, *The Cotton Trade*, p. 138. Other companies that were run as 'investment unions' and owned by those who 'know nothing of the business carried on' performed poorly in contrast; Royal Commission, 1886, q.5275).
 25. Webb, *The History of Trade Unionism*, p. 478-9.
 26. P. Cottrell, *Industrial Finance 1830-1914: The Finance and Organisation of English Manufacturing Industry* (London, Methuen: 1980), p. no; Farnie, *English Cotton*, p. 266.
 27. J. White, 'Lancashire Cotton Textiles', in C. Wrigley (ed.) *A History of British Industrial Relations* (Brighton, Harvester Press: 1982), p.216; Royal Commission on Labour, *Minutes of Evidence*, 1892, qq. 95-6, 190-3, 2548, 3608-9)
 28. Farnie, *English Cotton*, p. 267
 29. *Textile Mercury*, 21 January 1893, p. 43.
 30. A simple average index of 20 Oldham companies, selected from the Oldham Chronicle share listing and with a value of 100 at June 1890 had fallen to 50.2 by March 1896. An index for companies quoted on the London stock exchange calculated from the data in K. Smith, and G. Home, 'An index number of securities, 1867-1914', London and Cambridge Economic Service, Special Memorandum, No. 37: 1934, columns i-io, pp. 14-15, showed corresponding figures of 100 and 128.3. This rate of decline in Lancashire was equivalent to the loss of value on the London share market in the crash of 1929-33.
 31. Turner, *Trade Union Growth*, p. 124.
 32. For example, a joint committee was established to consider 'the opening of new markets abroad, the alteration of restrictive tariffs, and other similar matters which may benefit of injure the cotton trade ...', Brooklands Agreement, 1893, Board of Trade Report on Wages and Hours of Labour, Part II, Standard Piece Rates, C. 7567, Vol. XXXI, pp. 9-11.
 33. Employers were allowed to move for up to a five per cent reduction in wages; conversely up to a five per cent increase could be requested by employees, as determined by the economic cycle; K. Burgess, *The Origins of British Industrial Relations* (London, Croom Helm: 1975) p. 233.
 34. For example in the wages dispute of 1897, the Employers cited heavy losses in justification of a proposed reduction in wages; *Times*, 6 November, i3(v)). In response, the operatives' representative argued: 'It may suit the word spinners of the Employers' Committee to air their eloquence in chattering about past losses, but if they are half as practical as they flatter themselves they are, they will drop their wailings and devote their energies to increasing their present gains'; *Times*, 13 November 1897, p. 13 (v).
 35. H.A.Turner, *Trade Union Growth, Structure and Policy: A Comparative Study of the Cotton Unions* (London, Alien and Unwin: 1962), p. 149.

36. H. A. Clegg, *The System of Industrial Relations in Great Britain* (Oxford, Basil Blackwell: 1972), pp.459-60.
37. For example the directors' coup at Sun Mill in 1905, Tyson, *Sun Mill*, pp. 295-6. Publication of detailed analysis of accounts, died out during the 1890s. The *Oldham Chronicle*, 31 December 1892, for virtually the last time, analysed the balance sheets of several companies showing profits, payments for cotton and charges, wages, receipts for yarn and waste, depreciation and amounts previously written off machinery, trade debtors and creditors, machinery and buildings valuations, and shareholders and loan holders claims. Apart from isolated instances (for example, the Leesbrook Spinning Company, 29 December 1894, 30 March 1895) the practice effectively ceased from 1893 onwards.
38. Turner, *Trade Union Growth*, pp. 146 and 374. The card room strikes at Sun, Hey and Neville mills in 1889 spread to 143 mills with the backing of organised short time; Tyson, *Sun Mill*, p. 267. The increasing collusion of the employers was also a response the frequent cornering of the raw cotton market by Liverpool merchants, *ibid*, p. 271).
39. Some have suggested that the structural break in the British economy of the 1890s was associated with a change in trend of real wages. The levelling of previously rising living standards was associated with the stagnation of British industry, W. Lewis, *Economic Survey, 1919-1939*, London: Allen and Unwin (1949; 6th edition 1963). pp. 74-5. Recent statistical estimates have suggested that whereas real wage growth did not decline by as much as previously thought, there was nonetheless a significant slow down in the 1900s, C. H. Feinstein, 'What really happened to real wages', *Economic History Review*, Vol. XLIII (1989); pp.351-2.
40. 'All records broken: Unprecedented profits', was the headline of the review of 1907, *Oldham Chronicle*, 28 December 1907.
41. A. Fowler, and T. Wyke, *The Barefoot Aristocrats: A History of the Amalgamated Association of Operative Cotton Spinners* (Littleborough: George Kelsall: 1987); W. Lazonick, 'Industrial relations and technical change: the case of the self acting mule', *Cambridge Journal of Economics*, Vol. 3 (1979) pp. 231-262.
42. J. H. Clapham, *An Economic History of Modern Britain; Machines and National Rivalries* (Cambridge, Cambridge University Press: 1951), p. 322.
43. Feinstein, 'What really happened to real wages?', p. 339.
44. *Textile Mercury*, 15 April and 2 November 1895.
45. J. Porter, 'Industrial Peace in the Cotton Trade 1875-1913', *Yorkshire Bulletin of Economic and Social Research*, 19, May (1967) pp. 49-59.
46. Board of Trade Report on Wages, q. 7567.
47. 'Cotton trade wages', *Oldham Chronicle*, 4 July 1908.
48. Toms, thesis, ch. 6.
49. Burgess. *The Origins of British Industrial Relations*, p. 232.
50. Joyce, *Work, Society and Politics*, pp. 339-40.
51. V. Lenin, *Imperialism: The Highest Stage of Capitalism* (London, Lawrence and Wishart: 1933); as an example of 'reformism', Mawdsley, the spinners' union leader was a Conservative party supporter. As a mouthpiece of the senior minders, the *Cotton Factory Times* represented the views of moderate trade unionism; Burgess, *The Origins of British Industrial Relations*, p. 249.
52. Burgess, *Origins of British Industrial Relations*, p. 248.
53. C. Macara, *Recollections by Charles Macara* (London, Cassell: 1922).
54. Although the formal Brooklands agreement broke down in 1905 (Turner, *Trade Union Growth*, p.) the spirit of the system remained in place, Porter, 'Industrial peace', pp. 49-61.
55. J. White, *Lancashire Cotton Textiles*, in C. Wrigley (ed.) *A History of British Industrial Relations* (Brighton: Harvester Press: 1982) pp. 222-5.
56. Lazonick, 'Industrial Relations', p. 254.
57. Toms, thesis, pp.347 and 406.
58. Defined here as the difference between the sales value of output and all non capital and labour based costs.

59. The companies for which such data was available for the years between these dates were Osborne, Eccles, Sun Mill, Werneth, and Whiteley; see Toms, thesis, table 1.2, p. 28, for source documents.
60. Layton, *The relations of capital and labour*, pp. 34-6.
61. Feinstein, 'What really happened to real wages?', p. 347.
62. Feinstein, 'What really happened to real wages?', p. 351; Feinstein's conclusion on cotton rested on the Smith and Home 'An index number', which only included companies with London quotations. Lancashire companies with local quotations enjoyed more equally if not more spectacular return to profit during the 1900s (see chapter 9, table 9.5)
63. Lazonick and Mass, 'Performance of British cotton', table i, p. 6.
64. The number of firms was used as a surrogate for the number of factories; the multi plant firm was a rarity, and even where the owners were the same, new factories were usually floated separately, thereby acquiring the status of an independent firm (see Toms, thesis, especially chapters 8 and 9).
65. This can be confirmed from the detailed figures for spinning presented by Lazonick and Mass, 'The Performance of British Cotton', appendix i, table Ai, p. 40. which show a 10.2 increase (output per operative, 1904, 7316 lbs; 1907, 8061 lbs) during the upswing years of 1904-7 on the basis of their single year output data and 5.3 increase (output per operative, 1904, 7220 lbs; 1907, 7604 lbs) when calculated on the basis of three year average output.
66. According to the detailed data in Lazonick and Mass, 'The Performance of British Cotton', appendix i, table Ai, p. 40. productivity increased by 4 between 1901 and 1912. Using the same data, a decline of 1.51 can be shown to have occurred in output per operative for the period 1901-13 (table 8, p. 21). Conclusions depend heavily on the years selected for measurement.
67. Sandberg, *Lancashire in Decline*, p. 97.
68. Chapman, *The Lancashire cotton industry*, p. 158.
69. Lazonick, *Industrial relations*, p. 253-7; Lazonick, 'Production relations', p. 505.
70. Rochdale Observer, 4 January, 1890, p. 6; Textile Mercury, 5 December 1896
71. Joyce, *Work, Society and Politics*, pp. 339-40.
72. Rochdale Observer, 13 April 1892. All the mills of the town, with one exception, were closed on the morning of James Heap's funeral in 1892, and flags flew at half mast above the mills, the school, the educational institute, and the Conservative club, each symbolising a locus of power and influence for the departed industrialist and his successors. Most of the local population appeared to turn out to pay their respects.
73. Rochdale Observer, 9 April 1892.
74. J.S.Toms, 'Growth Profits and Technological Choice: The Case of the Lancashire Cotton Textile Industry', *Journal of Industrial History*, Vol. i (1998), p. 42, compares wages per hand and spindles per hand for the four ring companies then in existence, the three Milnrow companies and Palm mill of Oldham with four Oldham mule companies.
75. Winterbottom, *Cotton spinning calculations*, p. 261. Jewkes and Gray, *Wages and labour*, p. 129.
76. Production at the throstle section of the Fielden spinning plant at Waterside was facilitated by an 'army of doffers', *Todmorden Advertiser*, 9 November 1889, p. 4.
77. According to the recollections of former ring spinners; Kenney, *Cotton Everywhere*, pp. 130-1.
78. Men-tens, 'The hours and cost of labour', p. 160; the mill at Roubaix had 13.3 operatives per 1000 spindles. The comparable figure for mule spinning was 4.86, or 206 spindles per operative (Wood, 'Factory Legislation', p. 316).
79. Toms, thesis, p. 98.
80. See above and the commentary in the Rochdale Observer, 13 April 1892.
81. Oldham Chronicle, 29 June 1912; Porter, 'Industrial peace' p. 55; Jewkes and Gray, *Wages and labour*, Ch. 9.
82. Fowler and Wyke, *The barefoot aristocrats*.
83. Burgess, *The origins of British industrial relations*, p. 239.
84. Wood, 'Statistics of wages', pp. 134-7.

85. For example in the debate between Sandberg and Lazonick; the data in Lazonick, 'Factor costs', appendices i and 2, was derived from Winterbottom, Cotton spinning calculations, although that source contained no supporting breakdown of its departmental labour cost statistics, pp. 272-3.
86. Winterbottom, Cotton spinning calculations, pp. 212-3.
87. Toms, 'Growth, Profits and Technological Choice'; material costs averaged 70.9 and 74.7 of total costs respectively for samples comparable ring and mule companies.
88. Table 5.3. The tendency was for ring mills to be in the high 60s and mule mills to be -in the low 70s.
89. The Osborne produced 32S/50S warp and 40S/70S weft; Worrall, Cotton spinners and manufacturers' directory, 1890.
90. BPP, Board of trade report, £.7567.
91. The flexibility of vertical specialisation and its advantages were noted in Jewkes, 'Is British Industry Inefficient?' pp. 9-10.
92. Lazonick, 'The Cotton Industry', pp. 21-2.
93. Blaug, 'The productivity of capital', appendix C, p. 379-
94. Burgess, 'The origins of British industrial relations', p. 232.